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Title:
Rocket engines

TECHNICAL FIELD

The present invention relates to a liquid fuel rocket engine member having a load bearing wall structure comprising a plurality of cooling channels for handling a coolant flow. The invention also relates to a method for manufacturing the rocket engine member.

BACKGROUND OF THE INVENTION

During operation, the heat load is very intensive inside a rocket combustion chamber. The walls of the combustion chamber must be cooled efficiently not to melt or in other ways destroy the structure. The most common way to cool the chamber wall is cooling by convection. The cool fuel and even the oxidizer is used for cooling.

The service life of the chambers is often a problem. Much care must be taken to ensure proper function. Inspection and repair in development and in use of the engines is costly. The service life is very much depending on the temperature level of the wall structure closest to the flame. The temperature gradient over the cooling channels generates thermal stress. The elevated temperatures degrade the material properties. Therefore, the service life is very strongly influenced by the temperature. Reduction of the temperature by 100 °K leads to about three times increase in service life and 10 times increase in creep life.

The intense heat load leads to stratification of the coolant. The coolant closest to the hot wall is heated which results in a temperature increase. The viscosity of the coolant is lowered leading to increased flow speed closest to the heated wall. Thus, the coolant is stratified with sharp temperature gradients. A large share of the coolant is only heated to a low temperature level, reducing the efficiency of the cooling system. The temperature difference in the coolant may be in the order of 600-700 °K. At the outer side of the cooling channel, near the outlet end, the coolant may still have the inlet temperature of 60 °K.

It has been proposed to enlarge the cooling surface of the cooling wall, for example by having longitudinal fins along the inside the channels. However, the fins need to have some height to penetrate the thermal boundary layer. The coolant flow speed will be slowed down in the gap between the fins in case they are made high and close together. Therefore, the increase in heat transfer is limited with this measure. Also, the bottom of the fins needs to be sharp to give room to a large number of fins. The sharp bottom is perpendicular to the first principle stress. The channel bottom represents an important stress concentration. The fins are delicate to manufacture. The width of the channels at the throat area is in the order of 1.0 mm, which means that the maximum width of one of three fins is 0.3 mm and the tip of the fin becomes infinitely thin.

Also, it has been proposed to make heat transfer more effective by increasing the channel wall surface roughness to generate turbulence in the coolant flow. The

surface roughness increases the v rtexes at the wall, but the effect is small with a very low viscosity fluent as hydrogen.

JP 60048127 teaches the use of a twisted steel band inside a horizontal cooling channel to force a secondary flow to avoid stratification. This method is proposed for application in nuclear plants at horizontal pipes in reactors, intermediate pump, heat exchanger and inlet nozzle of steam generator. The steel band may lead to hot spots at the hot side and overheating of the material due to a reduced flow of coolant in the channel.

SUMMARY OF THE INVENTION

An object of the present invention is therefore to provide a rocket engine member with a reduced stratification of the coolant inside the cooling channels.

This is achieved by means of the member according to the invention, which is characterized in that each cooling channel is provided with a flow guiding surface extending at an angle to the cooling channel axis, for providing the axial coolant flow with an added radial directional flow component. The flow guiding surface forces the coolant to rotate as it flows through the channel, so that stratification is avoided.

The method according to the invention is characterized by the steps of shaping a sheet metal surface to provide a flow guiding surface, folding the sheet metal into cooling channels, and attaching the cooling channels to the wall structure.

Advantageous embodiments of the invention can be derived from the subsequent contingent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described in the following, in a non-limiting way with reference to the accompanying drawings in which:

FIG 1 is a schematic longitudinal section through a rocket combustion chamber according to the invention,

FIG 2 shows in a larger scale a longitudinal section through a cooling channel of the combustion chamber shown in Fig. 1, according to a first embodiment of the invention,

FIG 3 is a section along the line B-B in Fig. 2,

FIG 4 is a section along the line A-A in Fig. 3,

FIG 5 is a section corresponding to Fig. 2, according to a second embodiment of the invention, and

FIG 6 is a section along the line C-C in Fig. 5.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows a diagrammatic and somewhat simplified side view of a rocket engine combustion chamber 10 that has been produced in accordance with the present invention. The combustion chamber is intended for use in rocket engines of the type using liquid fuel, for example liquid hydrogen. The working of such a rocket engine is previously known per se and is therefore not described in detail here. The combustion chamber 10 is cooled with the aid of a cooling medium that is preferably also used as fuel in the particular rocket engine. The invention is however not limited to combustion chambers of this type.

The combustion chamber 10 is manufactured with an outer shape that forms a body of revolution having an axis of revolution and a cross section that varies in diameter along said axis.

The combustion chamber wall is a structure comprising a plurality of mutually adjacent cooling channels 11 extending substantially in parallel to the longitudinal axis of the combustion chamber 10 from the inlet end manifold 12 to its outlet end manifold 13. The outside of the structure includes a one piece pressure jacket 14. The U-formed cooling channels 11 are curved in the longitudinal direction to conform to the jacket contour and they are axially oriented along the wall, in this position, they are jointed to the metal jacket wall by brazing.

In the embodiment according to figures 2-4, each cooling channel 11 has an internal flow guiding surface comprising a plurality of protruding ribs 15 extending at an angle to the axis of the cooling channel. The angle of the ribs will force the coolant to rotate inside the channel as the coolant flows along the channel. In this way unheated coolant will be transported from the outside of the channel to the inside and heated coolant will be transported from the inside of the channel to the outside.

It will be possible to reduce the temperature of the combustion chamber by 100 °K by replacing about 15% of the already heated coolant with unheated coolant. The radial flow speed of the coolant should then be around 15% of its axial speed. This represents an angle of 9 degrees

from the axial speed vector. This small angl imposes only a small pressure drop to the coolant flow.

The ribbed channel surface increases the small vortexes and the friction at the hot side, also contributing to an increased heat transfer. Instead of the ribbed surface of figures 2-4, the surface may be provided with grooves in the channel wall. The topology should be rather smooth at the hot side of the channel where the service life limiting location is, to reduce the stress concentrations.

Figures 5 and 6 show a second embodiment of the invention, where the flow guiding surfaces are provided in the channel by means of a separate insert structure 16 having external thread portions 17. The structure 16 is adapted to be firmly fixed in the channel. As there are no thread portions 17 at the inner side of the channel wall 18, the insert does not block the coolant from access to the hot wall. As an alternative to the insert 16 shown in figures 5 and 6, the insert may be a helical spiral without a central core.

The channels 11 may have a smaller cross section at the inlet manifold 12 than at the outlet manifold 13. Preferably, separate cooling channel elements are stamped to present the desired ribbed or grooved surface structure. These elements are folded to the desired tapering channel width. Finally the separate channels are mounted into the rotational symmetric chamber and brazed. Thus, the manufacture of jacket and manifolds is simplified.

As an alternative, the surface structur may be applied to channels with parallel sides. This could be done by removal of material, e.g. by means of electro discharge machining.

The invention is not limited to the above-described embodiments, but several modifications are possible within the scope of the following claims. For example, the improved cold wall structure may also be applied to external expansion rocket engines like round and linear aero-spike engines. The flow guiding surface do not have to extend along the entire length of the cooling channel. Thus, the flow guiding surface can be applied to a part of the cooling channel subjected to the highest thermal load, e.g. the throat region.

C.13510, 2001-01-09

CLAIMS

1. A liquid fuel rocket engine member (10) having a load bearing wall structure (11, 14) comprising a plurality of cooling channels (11) for handling a coolant flow,
c h a r a c t e r i z e d in
that each cooling channel (11) is provided with a flow guiding surface (15; 17) extending at an angle to the cooling channel axis, for providing the axial coolant flow with an added radial directional flow component.

2. A member according to claim 1,
c h a r a c t e r i z e d in
that the flow guiding surface (15) is incorporated into the channel wall (18).

3. A member according to claim 2,
c h a r a c t e r i z e d in
that the flow guiding surface comprises a plurality of grooves in the channel wall (18).

4. A member according to claim 2 or 3,
c h a r a c t e r i z e d in
that the flow guiding surface comprises a plurality of ribs protruding (15) from the channel wall (18).

5. A member according to any one of claims 1,
c h a r a c t e r i z e d in
that the flow guiding surface is a separate structure (16) inside the cooling channel (11).

6. A member according to claim 5, c h a r a c t e r i z e d in that the structure comprises a helical spiral.

7. A member according to claim 5, c h a r a c t e r i z e d in that the structure comprises a threaded screw (16, 17).

8. A method for manufacturing a liquid fuel rocket engine member (10) having a load bearing wall structure (11, 14) comprising a plurality of cooling channels (11) for handling a coolant flow,
c h a r a c t e r i z e d in the steps of

shaping a sheet metal surface to provide a flow guiding surface (15),

folding the sheet metal into cooling channels (11), and

attaching the cooling channels (11) to the wall structure (14).

9. A method according to claim 8, c h a r a c t e r i z e d in that the sheet metal surface is shaped by stamping grooves into the surface.

10. A method according to claim 8, c h a r a c t e r i z e d in that the sheet metal surface is shaped by stamping to form protruding ribs (15) on the surface.

ABSTRACT

The invention relates to a liquid fuel rocket engine member (10). The member has a load bearing wall structure (11, 14) comprising a plurality of cooling channels (11) for handling a coolant flow. Each cooling channel (11) is provided with a flow guiding surface (15; 17) extending at an angle to the cooling channel axis, for providing the axial coolant flow with an added radial directional flow component.

(Fig. 2)

Fig. 1

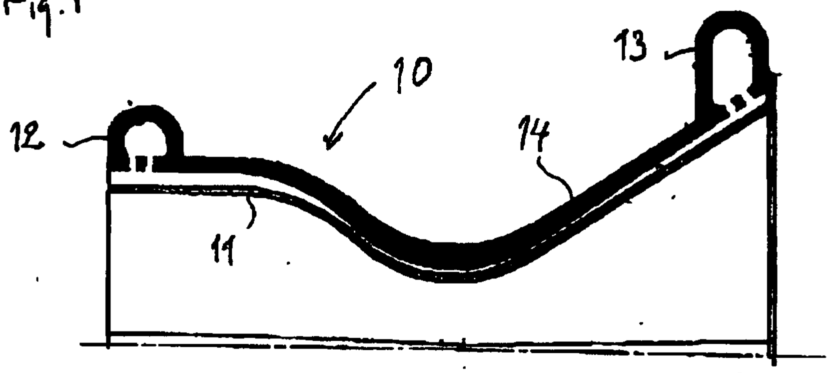

Fig. 4

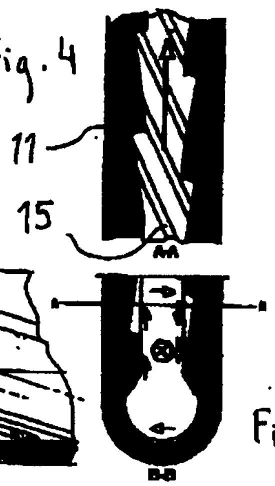

Fig. 3

Fig. 2

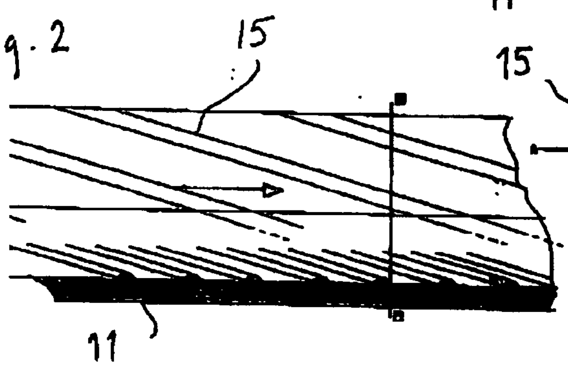

Fig. 5

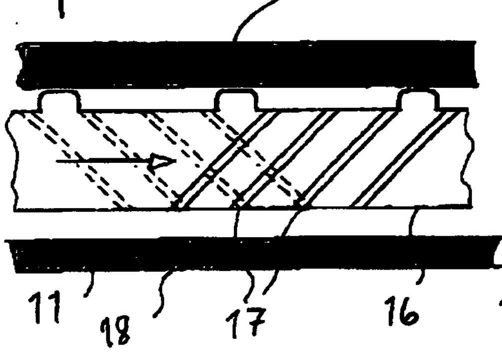

Fig. 6